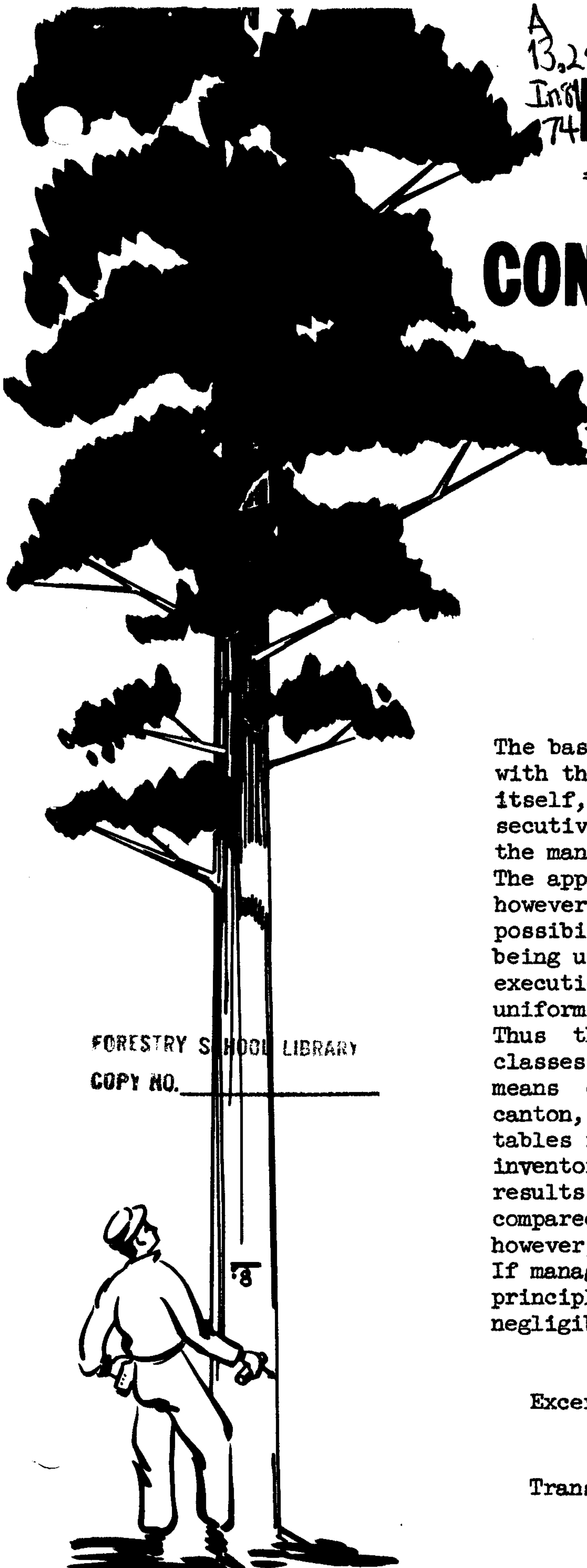

FOREST CONTROL by CONTINUOUS INVENTORY

"Today I have grown taller from walking
with the trees."
...Karle Wilson

Milwaukee, Wis. May, 1960 No. 74

FOREST MANAGEMENT IN SWITZERLAND
THE CHECK METHOD

By

Professor Herman Knuchel

Part 1

The basic idea of the check method is to experiment with the treatment; that is, to study in the forest itself, the behaviour of the production through consecutive enumerations. This concept runs through the management of all public forest in Switzerland. The application of these principles varies greatly however, from one region to another, and all the possibilities of the check method are far from being utilized to their full extent. The practical execution of the method is more reliable and uniform than the application of the principles. Thus the inventories are made on bases of size classes---the growing stock volume is calculated by means of a single volume table used over a whole canton, or by local volume tables, or by different tables for each species. The lower limit of the inventory also varies. --- It is clear that the results gained by methods so varied can only be compared from one region to another with great care; however, a comparison is not absolutely necessary. If management assures and checks the sustention principle, the requirements of statistics are negligible quantities.

Excerpt from "Die Forsteinrichtung in der Schweiz"
A. Kurth, Zürich

Translation by W. W. Jeffrey, 1954

WILL WE GROW ENOUGH TIMBER TO MEET OUR FUTURE NEEDS?

This is the question asked by Richard E. McArdle, Chief of the U. S. Forest Service, in a recent address entitled, "The Sixties--Decade of Decision". We can lean upon God's bounty of old growth timber on our shelves for a while, but by the end of the century, cautions Mr. McArdle, we will have to grow what we use.

The Chief Forester also implies that we will have to gain a more explicit knowledge of the growth of forests than the first 50 years of forestry have given us. This knowledge the Sixties promise to provide on many forest lands, for it will be the decade of CFI remeasurement as well as the Decade of Decision. It is interesting to trace the historic events leading up to this specialization in growth recording, and to speculate on its importance to the future of the forests in Region 9.

Forest survey began on a national scale in the early thirties and temporary inventory plots were established on a statewide basis in the chief forest areas. Line plot cruising predominated.

During the late forties public, industrial, and farm woodlot forests were first inventoried with permanent, fixed radius plots for the determination of volumes, growth and mortality.

In the fifties inventory controls began in earnest on industrial forest lands, and some public foresters also began to set out permanent, fixed radius plots on a systematic grid.

The study of forest changes, and the allowable cut, growth, and mortality hovered in the background of all these productive years of inventory work. Now the fateful Nineteen Sixties are on our backs. With them we see a continuation of industrial CFI, an increase in National Forest inventories, and Forest Survey is beginning its second great round of cruises on a regional basis. A great many more permanent plots are being included in the public forest surveys than heretofore, and this gives new emphasis to the plans for a better knowledge of growth in the forest. Perhaps long before the turn of the century we really will know how much wood we are growing, and how much more work we will need to grow enough more wood to supply our national needs.

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STATISTICAL PROCEDURE LEAFLET #4

HOW TO CALCULATE THE LIMIT OF ERROR (E_t)

Occasionally the average volume calculated from a set of sample plot records is exactly correct. Usually, the calculated volume is greater than, or less than, the true volume. We never know, nor can we calculate, the actual error. However, we can calculate a limit beyond which there is little likelihood that our error will go. When the size of the calculated limit is small in comparison with the calculated average volume itself, we consider our calculated average volume to be good, and usable. When the limit is large, we know that there may be a large error in our calculated average volume. Even so, we still do not know that a large error exists nor what the exact amount of error may be.

The first step in exploring the limits which confine our error is to determine the Standard Error. This is calculated from the Standard Deviation and the number of sample plots. 1/

$$\text{Standard error } (\sigma_M) = \frac{\text{Standard deviation } (\sigma)}{\sqrt{\text{Number of sample plots } (N)}}$$

$$= \frac{\pm 1.109 \text{ cords}}{\sqrt{12 \text{ plots}}}, \text{ or } \frac{\pm 1.109}{3.464} = \pm .320 \text{ cords}$$

The next step deals with laws of chance--the probability that a certain event will occur. Because we cannot calculate the exact error of our cruise (we do not know what the actual volume is), we shall calculate a Limit of Error for a selected Probability. This we do by using a relationship which exists be.ween the limit of error, the probability, and the standard error.

$$\text{Limit of error } (E_t) = \text{Probability factor } (t) \times \text{Standard error } (\sigma_M)$$

Probability factors vary slightly with the number of samples used. For CFI purposes these (t) factors may be considered to be constants. Suppose we choose odds of 21 to 1 that our calculated limit of error will not be exceeded. For this probability (about 95%) the factor (t) is approximately 2. (t = 1 for odds of about 2 to 1, t = 3 for odds of about 371 to 1). Using t = 2, we calculate the limit of error:

$$E_2 = (2) \times (\pm 0.320 \text{ cords}), \text{ or } \pm 0.640 \text{ cords.}$$

A last step converts this figure into a percent, in which form it expresses the confidence we may put in the calculated average volume. (One must never be misled into thinking the limit of error expressed in volume has any usefulness whatsoever, for it cannot be ascribed any direct relationship to the actual volume error that does exist). Dividing by the calculated average volume, we have:

$$\text{Limit of error } (\%) = \frac{\pm 0.640 \text{ cords}}{3.140 \text{ cords}} = \pm 0.204, \text{ or } (\pm 20.4\%) =$$

The data processing machine formula used to calculate the Limit of Error directly from the records is: 1/

$$\text{Limit of Error } (\%) = t\sqrt{\left(\frac{N(\Sigma X^2)}{(\Sigma X)^2} - 1\right)\left(\frac{1}{N-1}\right)}$$

1/ For data and symbols, see C.F.I. Newsletter #71, February, 1960 -- Statistical Procedure Leaflet #3.

William Warren Barton, Forester, U.S.F.S. Region 7

STATISTICAL PROCEDURE LEAFLET #6

HOW WE USE THE COEFFICIENT OF VARIATION (c)

The key to successful sampling is the coefficient of variation. There is a basic relationship between the coefficient of variation, the limit of error, the probability, and the number of samples. This relationship is:

$$N = \frac{t^2 c^2}{(E_t)^2}$$

where: N = number of samples

t = t-factor for probability (1 for probability of 68%, 2 for probability of 95%) 1/

c = coefficient of variation

E_t = limit of error for indicated probability

If we wish the error in our average to be no greater than ± 8% with a probability that this error will not be exceeded in 95% of the cruises made with the number of plots calculated; then:

$t = 2$ and $t^2 = 4$

$E_t = .08$ and $(E_t)^2 = .0064$

and the formula now becomes:

$$N = \frac{4\ c^2}{.0064}, \text{ or } N = 625\ c^2$$

Thus, after we set the limit of error and the probability, to determine the number of plots requires only that we have a figure to assign to the square of the coefficient of variation.

If we have already calculated coefficients of variation for stands similar to the one we are considering, we may select a figure to use in the formula. Suppose c^2 for similar stands to be .50, then:

$N = 625\ (.50)$, or 312 sample plots are required.

If we have no figures for c^2, we may be able to borrow some. 2/ When nothing is available, we may make an initial cruise, guessing the number of sample plots on the light side; calculate the square of the coefficient of variation; then, determine the total number of samples needed.

There are bare facts which apply to any stand (or fraction thereof, such as a single species) for which the coefficient of variation is available. In CFI, future as well as present stand conditions must be considered, and control of accuracy may be set at some point within the breakdown into smaller categories than the over-all total present volume.

1/ These approximate (t) values are usually adequate for CFI calculations.

2/ See C.F.I. Newsletter #34, January, 1957 - THE STATISTICAL CHECK SHEET, page 2, TABLE OF STAND FACTORS.

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